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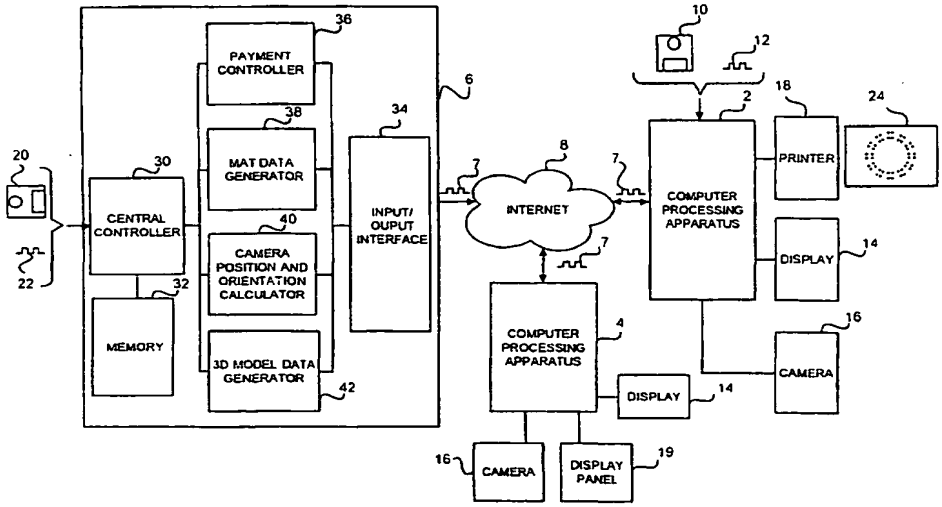
[Continued on next page]

(54) Title: IMAGE PROCESSING APPARATUS



(57) Abstract: Customer computer processing apparatus (2, 4) are connected to a service apparatus (6) via the Internet (8). Service apparatus (6) processes requests and payment details from a customer apparatus (2, 4), and, in response to a valid payment, sends instructions to the customer apparatus to enable the customer apparatus to control a printer (18) or a display panel (19) to print or display a photographic mat (24). Service apparatus (6) retains details of the photographic mat pattern for subsequent use. Images of a subject object on the photographic mat are recorded at different positions and orientations with a camera (16). Data defining the images is returned from the customer processing apparatus (2, 4) to the service apparatus (6). The service apparatus processes the image data along with the stored pattern data to identify the photographic mat features in the images and to calculate the position and orientation at which each image was recorded. A three-dimensional computer model of the subject object is then generated using the calculated positions and orientations.

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, IBM-TDB, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 815 683 A (VOGLER JOE E) 29 September 1998 (1998-09-29) claim 1 --- -/--	1,10,11, 18-20, 28,29, 37,38, 43,44, 48,53, 54,59, 60,64, 65,69,70

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Perez Molina, E

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 930 583 A (XEROX CORP) 21 July 1999 (1999-07-21) claim 1	1,10,11, 18-20, 28,29, 37,38, 43,44, 48,53, 54,59, 60,64, 65,69,70
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A	EP 0 790 584 A (SANYO ELECTRIC CO) 20 August 1997 (1997-08-20) page 15, line 44 -page 16, line 8	1
A	EP 0 794 517 A (CANON KK) 10 September 1997 (1997-09-10) column 7, line 42 -column 8, line 41	1
A	EP 0 794 516 A (CANON KK) 10 September 1997 (1997-09-10) column 1, line 1 -column 5, line 8	1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

In ational Application No
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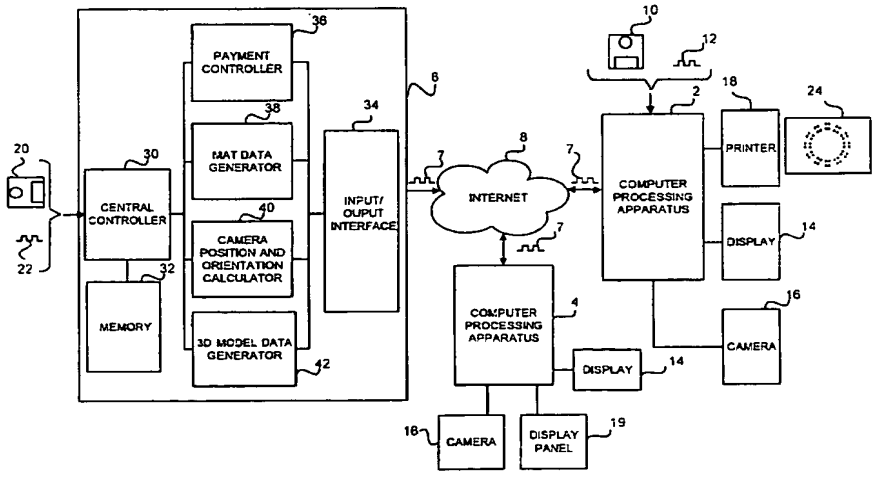

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IMAGE PROCESSING APPARATUS

The present invention relates to the recording of images of an object and the processing of the image data to determine the position and orientation at which the images were recorded, and to generate data defining a three-dimensional (3D) computer model of the object.

3D computer models of objects are useful for many applications. In particular, there is now a growing demand from members of the public to have 3D computer models of objects for uses such as the embellishment of Internet sites, etc.

However, conventional products for generating 3D computer models of an object are both expensive and require considerable processing resources (that is, processing power and/or time). Consequently, this restricts the availability of 3D computer modelling packages to users.

The present invention has been made with this in mind.

According to the present invention, there is provided a system or method for generating three-dimensional computer models of objects using a technique in which an

object is imaged at the same time as a calibration pattern, the images are processed to determine the positions and orientations at which they were recorded, and the images and positions and orientations are processed to generate a 3D computer model of the object. Data defining the calibration pattern is stored in a first computer processing apparatus, and data is sent to a customer computer processing apparatus to enable the customer apparatus to print or display the calibration pattern. Images of a subject object together with the calibration pattern are then recorded and returned to the first apparatus, which performs processing using the stored data defining the calibration pattern to determine the positions and orientations at which the images were recorded. Subsequently, a three-dimensional computer model of the subject object is generated using the calculated positions and orientations.

By storing data defining the calibration pattern in a first apparatus, transmitting calibration pattern data to the customer apparatus, and performing the imaging position and orientation calculations in the first apparatus, the user is not required to purchase expensive processing products, or to run a resource-intensive product on his apparatus. Instead, computationally

expensive processing can be performed in a supplier's apparatus, and the user can pay a small fee each time the processing services offered by the supplier are used, this being enabled by the transmission of calibration pattern data to the user and the storage of data defining the calibration pattern which will appear in the return images.

The present invention also provides separate apparatus for making up the system above.

The present invention further provides computer program products for configuring programmable processing apparatus for use in the system above.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 schematically shows the components of a first embodiment of the invention, together with the notional functional processing units into which the computer components may be thought of as being configured when programmed by programming instructions;

Figure 2 shows the processing operations performed by the apparatus in the system of Figure 1 to generate data defining a 3D computer model of an object;

Figure 3 shows the components of a second embodiment of the invention, together with the notional functional processing units into which the computer components may be thought of as being configured when programmed by programming instructions; and

Figure 4 shows the processing operations performed by the apparatus in the system of Figure 3 to generate data defining a 3D computer model of an object.

Referring to Figure 1, a first embodiment of the invention comprises a plurality of computer processing apparatus 2, 4, 6 connected to exchange data by transmitting signals 7 via a communications network 8, such as the Internet.

In this embodiment each processing apparatus 2, 4 is used by a customer, and has connected thereto a display device 14, such as a conventional personal computer monitor and a digital camera 16. In addition, the processing apparatus 2 has connected thereto a printer 18, and

processing apparatus 4 has connected thereto a flat display panel 19 having controllable pixels, such as the PL400 manufactured by WACOM.

Each of the processing apparatus 2, 4 is a conventional personal computer programmed to operate in accordance with programming instructions input, for example, as data stored on a data storage medium, such as disk 10, and/or as a signal 12 input to the processing apparatus 2, 4, for example from a remote database, by transmission over a communication network such as the Internet 8 or by transmission through the atmosphere and/or entered by a user via a user input device such as keyboard (not shown). The programming instructions for each processing apparatus 2, 4 may be supplied either in compiled, computer executable format or in a format (such as source code) for conversion to a compiled format.

Processing apparatus 6 is provided by a 3D modelling service provider. In this embodiment, processing apparatus 6 comprises a conventional programmable computer, containing in a conventional manner, one or more processors, memories, graphics cards, etc.

The processing apparatus 6 is programmed to operate in

accordance with programming instructions input, for example, as data stored on a data storage medium, such as disk 20 and/or as a signal 22 input to the processing apparatus 6, for example from a remote database, by transmission over a communication network such as the Internet 8 or by transmission through the atmosphere and/or entered by a user via a user input device such as a keyboard (not shown). The programming instructions for processing apparatus 6 may be supplied either in compiled, computer executable format or in a format (such as source code) for conversion to a compiled format.

As will be described in more detail below, the programming instructions comprise instructions to cause the processing apparatus 6 to become configured to process payments from a user, and in response to a valid payment, to transmit instructions to a connected customer computer processing apparatus 4, 6 to enable the customer apparatus to control printer 18 to print a calibration pattern thereby to form a calibration object which, in this embodiment, comprises a photographic mat 24 having a special pattern of features thereon, or to control a display panel 19 to display the calibration pattern so that the display displaying the features of the calibration pattern acts as a photographic mat. The

programming instructions further cause the processing apparatus 6 to become configured to process data received from a customer computer processing apparatus 2, 4 defining images of a subject object and the photographic mat so as to calculate the positions and orientations at which the images were recorded by detecting the positions of the features of the photographic mat pattern (calibration pattern) in the images, and to use the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object which is transmitted to the paying user. When programmed by the programming instructions, processing apparatus 6 can be thought of as being configured as a number of functional units for performing processing operations. Examples of such functional units and their interconnections are shown in Figure 1. The units and interconnections illustrated in Figure 1 are, however, notional and are shown for illustration purposes only to assist understanding; they do not necessarily represent units and connections into which the processor, memory etc of the processing apparatus 6 become configured.

Referring to the functional units shown in Figure 1 a central controller 30 provides control and processing for

the other functional units, and a memory 32 is provided for use by central controller 30 and the other functional units.

An input/output interface 34 is arranged for the output of signals 7 to, and receipt of signals 7 from, the connected customer computer processing apparatus 2, 4.

A payment controller 36 is arranged to perform processing operations to obtain and check payments from a customer computer processing apparatus 2, 4.

A mat data generator 38 generates control signals which are sent as signals 7 to customer processing apparatus 2 to enable customer apparatus 2 to control printer 18 to print a calibration pattern on a recording medium such as a piece of paper to form a photographic mat 24, or to customer processing apparatus 4 to enable customer apparatus 4 to control display panel 19 to display the calibration pattern to form the photographic mat. As will be described in more detail below, the photographic mat comprises a pattern of features (calibration pattern), and the subject object(s) for which a three-dimensional computer model is to be generated is placed on the printed photographic mat 34 or on the display

panel 19 on which the photographic mat is displayed. Images of the subject object on the photographic mat are then recorded by a camera 16 and returned to the processing apparatus 6 as signals 7 for processing. Mat data generator 38 stores in memory 32 data defining the calibration pattern printed or displayed to form the photographic mat for use by the processing apparatus 6 in calculating the positions and orientations at which the received images were recorded.

Camera position and orientation calculator 40 processes the received data defining a plurality of images of the subject object(s) and the printed or displayed photographic mat to calculate the position and orientation of the camera 16 when each image was recorded.

3D model data generator 42 processes the received data defining the images and the data defining the positions and orientations at which the images were recorded to generate data defining a 3D computer model of the object(s) in the images.

Figure 2 shows the processing operations performed by processing apparatus 6 and one of the customer computer

processing apparatus 2, 4 in the first embodiment. Communication between the processing apparatus 6 and the customer computer processing apparatus is by the transmission of signals 7 over the communication network 8.

Referring to Figure 2, at step S2-2, a customer processing apparatus 2, 4 transmits a request to processing apparatus 6 for a 3D modelling service.

At step S2-4, payment controller 36 of processing apparatus 6 logs the request, and at step S2-6 transmits a signal to the customer processing apparatus requesting payment details, for example a credit card number or identification of an account which the customer holds with the operator of processing apparatus 6.

At step S2-8, the customer processing apparatus receives the payment request, and at step S2-10 sends the requested payment details.

At step S2-12, payment controller 36 in processing apparatus 6 receives the payment details sent by the customer processing apparatus and checks the details, for example to confirm the credit card payment with an

authorisation agency or to check whether the customer's account is in credit.

It is determined at S2-12 that a satisfactory payment has been made, then, at step S2-14, mat data generator 38 requests data from the customer processing apparatus defining the type of printer 18 or display panel 19 which is to print or display the photographic mat, and also data defining the maximum width in any direction of the object to be placed on the photographic mat.

At step S2-16, the customer processing apparatus receives the request for printer/display details and object size, and at step S2-18, sends the requested details to the processing apparatus 6.

At step S2-20, mat data generator 38 selects at random a calibration pattern for the photographic mat from patterns prestored in memory 32, and stores data in memory 32 defining which pattern has been selected.

More particularly, in this embodiment, calibration patterns comprising concentric circles connected by radial line segments with known dimensions and position markers in each quadrant, for example as described in

"Automatic Reconstruction of 3D Objects Using a Mobile Camera" by Niem in Image and Vision Computing 17 (1999) pages 125-134, patterns comprising concentric rings with different diameters, for example as described "The Lumigraph" by Gortler et al in Computer Graphics Proceedings, Annual Conference Series, 1996 ACM-0-89791-764-4/96/008, patterns comprising coloured dots with each dot having a different hue/brightness combination so that each respective dot is unique, for example as described in JP-A-9-170914, and patterns comprising spatial clusters of features for example as described in the assignee's PCT application filed concurrently herewith which claims priority from UK patent applications 9927678.4 and 0012812.4 and has attorney reference CFP1662WO 2714299 (the full contents of which are incorporated herein by cross-reference) are stored in memory 32.

In this embodiment, the features on the photographic mat are arranged around a blank central area on which the subject object is to be placed. Mat data generator 38 selects the diameter of the central blank area to be larger than the maximum width of the object defined in the data received from the customer processing apparatus. In this way, the features in the calibration pattern on

the photographic mat are positioned so that they will be visible when the object is placed on the mat.

At step S2-22, mat data generator 38 generates a command file for use by the customer processing apparatus to cause printer 18 to print a photographic mat having the calibration pattern selected at Step S2-20, or for use by processing apparatus 4 to cause display panel 19 to display a photographic mat with the calibration pattern selected at step S2-20. More particularly, in this embodiment, mat data generator 38 generates the command file in dependence upon the type of printer or display defined in the details received from the customer apparatus, so that the instructions in the command file are suitable for enabling the customer apparatus to control the printer or display panel connected to the customer processing apparatus.

At step S2-24, the command file generated at step S2-22 is sent from processing apparatus 6 to the customer processing apparatus.

At step 2-26, the customer processing apparatus stores the received command file sent from the processing apparatus 6, and at step S2-28, the customer processing

apparatus uses the command file to print the calibration pattern using printer 18 to form a photographic mat 24 or to display the calibration pattern to form a photographic mat on display panel 19.

Having printed or displayed the photographic mat, the subject object (or objects) for which a 3D computer model is to be generated, is placed in the blank centre portion of the photographic mat, so that the object is surrounded by the calibration pattern features on the mat.

Images of the object and the photographic mat are then recorded at different positions and orientations using a camera 16 to show different parts of the subject object. More particularly, in this embodiment, camera 16 remains in a fixed position (for example a tripod) and the photographic mat with a subject object thereon is moved (translated) and rotated, and photographs of the subject object at different positions and orientations relative to the camera 16 are recorded. During the rotation and translation of the photographic mat, the subject object does not move relative to the mat.

At step S2-30, the customer processing apparatus receives data defining the recorded images showing the subject

object(s) on the photographic mat, and at step S2-32, sends the image data to the processing apparatus 6.

In Figure 2, steps S2-26 to S2-32 described above are shown as occurring without interruption. However, after receiving and storing the command file step at S2-26, connection between the customer processing apparatus and the processing apparatus 6 may be broken while the user of the customer processing apparatus performs step S2-28, records images of the subject object and calibration pattern, and inputs the image data to the customer processing apparatus. The steps of printing or displaying the calibration pattern, recording the images of the subject object and calibration pattern, and inputting the image data to the customer processing apparatus need not occur immediately after receiving and storing the command file at step S2-26. For example, these steps may be performed one or more days later. Similarly, images of the subject objection and calibration pattern may be taken one or more days after printing or displaying the calibration patten in step S2-28. Consequently, when step S2-32 is performed to send image data from the customer processing apparatus to the processing apparatus 6, it may be necessary to re-establish a connection from the customer processing

apparatus to the processing apparatus 6 via the network 8.

At step S2-34, processing apparatus 6 stores the image data received from the customer processing apparatus in memory 32, and at step S2-36, processes the image data to calculate the position and orientation of the camera 16 for each image.

More particularly, at step S2-36, camera position and orientation calculation 40 performs processing first to calculate the values of the intrinsic parameters of the camera 16 which recorded the images (that is, the aspect ratio, focal length, principal point, first order radial distortion coefficient and skew angle) in a conventional manner, for example as described in "Euclidean Reconstruction from Uncalibrated Views" by Hartley in Applications of Invariance in Computer Vision, Mundy Zisserman and Forsyth Eds at pages 237-256, Azores, 1993. Camera position and orientation calculator 40 then performs processing for each respective image to detect the features of the calibration pattern on the photographic mat in the image, to label the features (that is, to identify a one-to-one correspondence between each feature detected in the image and a feature of the

calibration pattern defined in the data previously stored in memory 32 at step S2-20), and to use the one-to-one correspondences to calculate the position and orientation at which the image was recorded. More particularly, in this embodiment, the processing to detect and label the features and to calculate the camera position and orientation is performed as described in "Automatic Reconstruction of 3D Objects Using a Mobile Camera" by Niem in Image and Vision Computing 17 (1999) pages 125-134, "The Lumigraph" by Gortler et al in Computer Graphics Proceedings, Annual Conference Series, 1996 ACM-0-89791-764-4/96/008, JP-A-9-170914 or the assignee's PCT application filed concurrently herewith which claims priority from UK Patent applications 9927678.4 and 0012812.4 and has attorney reference CFP1662WO 2714299, depending upon the mat pattern selected at step S2-20.

At step S2-38, 3D model data generator 42 in processing apparatus 6 performs processing using the image data previously stored at step 2-34 and the position and orientation of each image calculated at step S2-36 to generate data defining a computer model of the 3D surface of the subject object and to generate texture data for the surface model. This processing is performed using one of the techniques described in "Automatic

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At step S2-40, 3D model data generator 42 transmits a signal 7 to the customer processing apparatus containing data defining the 3D computer model generated at step S2-38.

At step S2-42, the 3D data file sent by processing apparatus 6 is stored in the customer processing apparatus, and at step S2-44, one or more images of the 3D computer model are rendered from user-selected viewing directions and are displayed to the user on display device 14.

At step S2-46, the customer processing apparatus reads input signals from a user defining whether the 3D computer model is of an acceptable standard.

If it is determined at step S2-46 that the 3D computer model is acceptable, then, at step S2-48, the 3D data file previously stored at S2-42 is made available for access via other apparatus by the Internet 8, in a conventional manner.

On the other hand, if it is determined at step S2-46 that the 3D computer model is not acceptable, then steps S2-30 to S2-46 are repeated. That is, further images of the subject object on the photographic mat are recorded and sent to processing apparatus 6, processing apparatus 6 performs processing using the further images to amend and improve the 3D computer model, and the improved model is transmitted to the customer processing apparatus. Steps S2-30 to S2-46 are repeated until a satisfactory 3D computer model has been generated.

Figure 3 shows the components of a second embodiment.

In the second embodiment, components which are the same as the first embodiment are labelled with the same reference number, and will not be described again here as they have already been described above.

The differences between the components in the second

embodiment compared to the components in the first embodiment are, firstly, an image data store 50 is provided in each customer computer processing apparatus 2, 4, and, secondly, the 3D model data generator 42 which was provided in processing apparatus 6 in the first embodiment is now provided in each customer computer processing apparatus 2, 4. All of the other components are the same.

Figure 4 shows the processing operations in the second embodiment.

Referring to Figure 4, steps S4-2 to S4-30 are the same as steps S2-2 to S2-30 in the first embodiment, and accordingly will not be described again here.

In the first embodiment, data defining images of the subject object and photographic mat is transmitted from a customer processing apparatus 2, 4 to processing apparatus 6, where it is processed to calculate the position and orientation of each image and to generate data defining a 3D computer model of the subject object. A 3D data file defining the 3D computer model is then returned from processing apparatus 6 to the customer processing apparatus.

In the second embodiment, however, processing to calculate the position and orientation at which each image is recorded is still carried out in processing apparatus 6, but processing to generate data defining a 3D computer model of the subject object is performed in a customer processing apparatus 2, 4.

More particularly, referring to Figure 4, at step S4-32, images of the subject object and the photographic mat are stored in the customer computer processing apparatus in image data store 50.

At step S4-34, the image data stored at step S4-32 is copied and sent from the customer computer processing apparatus to the processing apparatus 6.

At step S4-36, processing apparatus 6 stores the received image data in memory 32, and at step S4-38, camera position and orientation calculator 40 performs processing to calculate the position and orientation of the camera 16 for each image. Step S4-38 is the same as step S2-36 in the first embodiment, and accordingly will not be described again here.

At step S4-40, processing apparatus 6 transmits a data

file defining the positions and orientations of the images calculated at step S4-38 to the customer processing apparatus.

At step S4-42, the customer computer processing apparatus stores the data file defining the positions and orientations, and at step S4-44, performs processing using the image data previously stored at step S4-32 and the positions and orientations stored at S4-42 to generate data defining a 3D computer model of the subject object. Step S4-44 is performed in the same way as step S2-38, and accordingly will not be described again here.

Steps S4-46 to S4-50 are the same as steps S2-44 to S2-48 in the first embodiment, and accordingly will not be described again here.

Many modifications can be made to the embodiments above within the scope of the present invention.

For example, the subject object does not need to be placed on the photographic mat. More particularly, the subject object may be placed alongside the mat and images recorded so that at least part of the object and calibration pattern are visible in each image.

Accordingly, the photographic mat does not need to be in a horizontal plane. It could, for example, be hung in a vertical plane behind the subject object.

In the embodiments described above, the printer instructions sent from processing apparatus 6 to a customer computer processing apparatus instruct printer 18 to print photographic mat 24 in accordance with the object size. If the size is so large that a photographic mat 24 cannot be printed on a single sheet of paper, then mat data generator 38 may generate data to control printer 18 to print different parts of the calibration pattern of the photographic mat 24 on separate sheets of paper, which can then be placed together to form the photographic mat 34.

Alternatively, mat data generator 38 may generate data to control printer 18 to print different parts of the calibration pattern on separate sheets and, instead of assembling the separate sheets to form a photographic mat 24 so that the features in the calibration pattern are at known predetermined positions stored in processing apparatus 6, the separate sheets with the different parts of the calibration pattern thereon may be placed around the subject object at positions and orientations chosen

by the user, so that the positions of the calibration pattern parts relative to each other are not known.

Images of the subject object and the different parts of the calibration pattern on the separate sheets would then be recorded at different positions and/or orientations by moving the imaging camera 16 relative to the subject object and the sheets.

In each input image, the features in each part of the calibration pattern are known (because mat data generator 38 sent data defining the features to be printed) but the relative positions of the different parts of the calibration pattern around the subject object are not known. Accordingly, camera position and orientation calculator 40 performs processing to detect the features of the calibration pattern in each image by searching each image to detect the predetermined features of the calibration pattern which are stored in memory 32, and then uses the detected features to calculate the positions and orientations of the images relative to each other.

More particularly, because camera position and orientation calculator 40 detects predetermined

calibration pattern features in the input images, as described in the embodiments above, camera position and orientation calculator 40 establishes a one-to-one-correspondence between features in each input image and stored calibration pattern features. These one-to-one correspondences therefore define features in different input images which correspond to each other, that is, features which match between the different input image. This is because, features in different input images which correspond to the same stored calibration pattern therefore correspond to (match) each other.

Camera position and orientation calculator 40 therefore performs processing to calculate the relative positions and orientations of the camera 16 for each input image using the matching features in the input images.

Many techniques are known for calculating relative imaging positions and orientations once matching features and input images have been detected. For example, suitable processing is described in EP-A-0898245 and EP-A-0901105.

In summary, therefore, in this modification, the photographic mat comprises a plurality of pieces, each

piece having part of the calibration pattern thereon. When images of the subject object and the photographic mat are processed, the features of the calibration pattern are known and prestored in processing apparatus 6 and can therefore be reliably detected by camera position and orientation calculator 40 in each input image. The input images are then processed by camera position and orientation calculator 40 to calculate the imaging positions and orientations relative to each other using the detected features to define matching features in the input images, and using the matching features to calculate the relative positions and orientations in a conventional manner.

Further, in the embodiments above, the calibration pattern may be attached to the subject object, and the camera moved relative to the subject object with the calibration pattern thereon to record the images at different positions and/or orientations. For example, one or more calibration patterns may be attached to different surfaces of the subject object.

In the embodiments above, processing apparatus 6 may generate the instructions for enabling the customer processing apparatus to print or display a calibration

pattern to form a photographic mat in dependence upon data received from the customer processing apparatus defining characteristics other than the size of the subject object. For example, processing apparatus 6 may generate the instructions in dependence upon the colour of the subject object so that the features in the calibration pattern on the photographic mat do not have the same colour as the subject object and can therefore easily be distinguished from features on the subject object.

The display panel 19 could comprise any form of display apparatus for displaying the calibration pattern of the photographic mat. For example, the display panel 19 could comprise the display of display device 14 which could be turned so that the display is horizontal if the object is to be placed on the photographic mat, or could be placed behind the object so that the display is in a substantially vertical plane.

In the embodiments described above, the calibration object which is imaged with the subject object has the form of a two-dimensional photographic mat. However, instead of a photographic mat, a three-dimensional calibration object may be used. For example, mat data

generator 38 may generate instructions to control printer 18 to print calibration patterns of features on separate sheets, and the sheets may then be folded into or attached to a three-dimensional object, such as a cube. The cube with the calibration pattern on it can then be used as a three-dimensional calibration object.

In the embodiments above, at step S2-20 and step S4-20, mat data generator 38 selects a calibration pattern from the patterns stored in memory 32 at random. However, calibration patterns may be selected in other ways. For example, the identity of the customer may be determined and a calibration pattern previously allocated to the customer selected. Further, mat data generator 38 may select a calibration pattern in dependence upon characteristics of the printer/display defined in the details received from the customer processing apparatus. For example, mat data generator 38 may select a calibration pattern in dependence upon whether the printer is a colour printer and the resolution of the printer. In this way, a calibration pattern with appropriate features for the printer can be selected.

In addition, processing apparatus 6 may store details of each customer's printer/display so that, when a customer

requests a service, the identity of the customer may be determined and the printer/display details read, so that it is not necessary for the customer to send the printer/display details.

In the embodiments described above, at steps S2-22 and S4-22, mat data generator 38 generates a command file to be used by the customer processing apparatus to control printer 18 or display panel 19. However, instead of generating and sending a printer or display command file, mat data generator may send data defining the calibration pattern selected at step S2-20 and S4-20. The customer processing apparatus would then generate its own instructions to control printer 18 or display 19 to print or display the calibration pattern.

In the embodiments above, processing is performed by camera position and orientation calculator 40 to calculate the intrinsic parameters of the camera 16 which was used to record images of the photographic matter and subject object. However, instead, the intrinsic parameters may be transmitted from the customer computer processing apparatus to processing apparatus 6 or, default values may be assumed for some, or all, of the intrinsic camera parameters.

In the embodiment above, each camera 16 is a digital camera connected to a customer processing apparatus. However, each camera 16 may be separate from a customer processing apparatus and may transfer data thereto via a memory device or a temporary connection etc. Further, images of the photographic mat and subject object may be recorded using a conventional film camera and a scanner connected to the customer computer processing apparatus may be used to scan photographs to generate digital image data for transmission to processing apparatus 6.

In the embodiments above, the 3D computer model generated by 3D model data generator 42 may be made available for access on the Internet 8 by processing apparatus 6 rather than a customer computer processing apparatus 2, 4.

In the embodiments above, if it is determined at step S2-46 (Figure 2) or step S4-48 (Figure 4) that a 3D model is not of an acceptable standard, then the model is improved by recording and processing further images. However, in addition, or instead, the model may be amended interactively by a user by displaying the model and moving, adding or deleting points or surfaces making up the model.

In the embodiments above, the customer computer processing apparatus 2, 4 to which photographic mat print or display instructions are sent by processing apparatus 6 is also the customer processing apparatus to which image data is input (step S2-30 or step S4-30) and which sends the image data to the processing apparatus 6 (step S2-32 or step S4-34). However, different customer computer processing apparatus may be used to print or display the photographic mat and to receive input image data and send the image data to the processing apparatus 6. For example, processing apparatus 6 may send print instructions to processing apparatus 2, which uses the instructions to control printer 18 to print a photographic mat 24. Photographic mat 24 and a subject object may then be imaged using a camera 16 and the image data input to a different customer processing apparatus 4, which transmits the image data to processing apparatus 6.

In the first embodiment above, the processing apparatus 6 sends the data file defining the 3D computer model generated by the 3D model data generator 42 back to the customer computer processing apparatus which sent the image data to the computer processing apparatus 6 for processing. However, instead, data defining the 3D

computer model may be sent to a different customer computer processing apparatus. For example, processing apparatus 6 may send print instructions to customer processing apparatus 2 which uses the instructions to control printer 18 to print a photographic mat 24. Customer computer processing apparatus 2 may also then return image data to the processing apparatus 6 for processing. However, instead of returning data defining the resulting 3D computer model to processing apparatus 2, processing apparatus 6 may send the data defining the 3D computer model to a different processing apparatus 4.

In the second embodiment described above, at step S4-32, the customer computer processing apparatus stores image data for subsequent use when data has been received from processing apparatus 6 defining the positions and orientations of the images to generate the 3D computer model data. Instead, however, to remove the need for the customer processing apparatus to store the image data, processing apparatus 6 may return the image data together with the data defining the position and orientation of each image to the customer processing apparatus.

In the second embodiment described above, the data defining the position and orientation of each image is

returned to the customer computer processing apparatus which sent the image data to the processing apparatus 6 for processing. However, the data defining the position and orientation results may be sent to a different customer computer processing apparatus together with the image data. For example, processing apparatus 6 may send print instructions to processing apparatus 2, which uses the instructions to control printer 18 to print a photographic mat 24 and processing apparatus 2 may return image data to processing apparatus 6. Processing apparatus 6 may then calculate the position and orientation of each image, and send the calculated positions and orientations together with the received image data to customer computer processing apparatus 4. Customer computer processing apparatus 4 may then process the received data to generate a 3D computer model of the subject object.

In the embodiments described above, two customer processing apparatus 2, 4 are described as connected to processing apparatus 6. However, more, or less, customer processing apparatus may of course be connected to processing apparatus 6.

In the embodiments described above, the functional

processing units of processing apparatus 6 are described as part of a single apparatus. However, the functional components may be provided in a number of separate apparatus which act together to constitute processing apparatus 6.

In the embodiments above, the communications network 8 connecting the computer processing apparatus 2, 4, 6 comprises a single network. However, the network may comprise a plurality of connected networks. One or more of the computer processing apparatus 2, 4, 6 may be connected to the network(s) via a wireless connection (for example radio signals). Of course, one or more connections between the computer processing apparatus 2,4, 6 may be a telephone connection.

In the embodiments described above, at steps S2-38 and S4-44 processing is performed to generate data defining a 3D computer model of the subject object, at steps S2-44 and S4-46, images of the 3D computer model are displayed, and at steps S2-48 and S4-50, the data defining the 3D computer model is made available for access. However, in addition, or instead, the imaging positions and orientations calculated at steps S2-36 and S4-38 may be used to control manufacturing equipment to manufacture a

physical model of the subject object. For example, data may be generated to control a cutting apparatus to cut material to the appropriate dimensions to model the subject object.

In the embodiments described above, processing is performed by computers using processing routines defined by programming instructions. However, some, or all, of the processing could be performed using hardware.

CLAIMS

1. A method of generating data defining a three-dimensional computer model of a subject object using connected computer processing apparatus, comprising:

sending from a first apparatus to a second apparatus data to allow the printing of a calibration pattern of distinguishable features by the second apparatus using a printing apparatus, and storing data in the first apparatus defining the calibration pattern for subsequent use;

printing the calibration pattern using the data from the first apparatus;

recording a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations, and sending data defining the images to the first apparatus;

performing processing in the first apparatus on the basis of the stored data defining the calibration pattern to calculate the positions and orientations at which at least some of the images were recorded; and

performing processing in the first apparatus using the calculated positions and orientations to generate data defining a three-dimensional computer model of the

subject object.

2. A method of generating data defining a three-dimensional computer model of a subject object using connected computer processing apparatus, comprising:

sending from a first apparatus to a second apparatus data to allow the printing of a calibration pattern of distinguishable features by the second apparatus using a printing apparatus, and storing data in the first apparatus defining the calibration pattern for subsequent use;

printing the calibration pattern using the data from the first apparatus;

recording a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations, and sending data defining the images to the first apparatus;

performing processing in the first apparatus on the basis of the stored data defining the calibration pattern to calculate the positions and orientations at which at least some of the images were recorded;

sending data defining the calculated positions and orientations from the first apparatus to a 3D modelling apparatus; and

performing processing in the 3D modelling apparatus using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

3. A method according to claim 1 or claim 2, wherein the data defining the images is sent from the second apparatus to the first apparatus.

4. A method according to claim 1 or claim 2, wherein the data defining the images is sent from a third apparatus to the first apparatus.

5. A method according to claim 2, wherein the 3D modelling apparatus is the second apparatus to which the print enabling data is sent.

6. A method according to claim 2 or claim 5, wherein image data for each image for which the position and orientation of the imaging means has been calculated is sent from the first processing apparatus to the 3D modelling apparatus together with the data defining the calculated positions and orientations.

7. A method according to any preceding claim, further comprising the step of sending data defining details of the printing apparatus from the second apparatus to the first apparatus, and wherein the print enabling data is generated by the first apparatus in dependence upon the details of the printing apparatus.

8. A method according to any preceding claim, further comprising the step of sending data defining a characteristic of the subject object from the second apparatus to the first apparatus, and wherein the print enabling data is generated by the first apparatus in dependence upon the characteristic of the subject object.

9. A method according to any preceding claim, wherein the data sent from the first apparatus to the second apparatus for enabling the second apparatus to control a printing apparatus to print the calibration pattern defines the calibration pattern as a plurality of respective parts to be printed on separate recording media.

10. A method of generating data defining a three-dimensional computer model of a subject object using

connected computer processing apparatus, comprising:

sending from a first apparatus to a second apparatus data to allow the display of a calibration pattern of distinguishable features by the second apparatus on a display apparatus, and storing data in the first apparatus defining the calibration pattern for subsequent use;

displaying the calibration pattern using the data from the first apparatus;

recording a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations, and sending data defining the images to the first apparatus;

performing processing in the first apparatus on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

performing processing in the first apparatus using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

11. A method of generating data defining a three-dimensional computer model of a subject object using

connected computer processing apparatus, comprising:

sending from a first apparatus to a second apparatus data to allow the display of a calibration pattern of distinguishable features by the second apparatus on a display apparatus, and storing data in the first apparatus defining the calibration pattern for subsequent use;

displaying the calibration pattern using the data from the first apparatus;

recording a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations, and sending data defining the images to the first apparatus;

performing processing in the first apparatus on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded;

sending data defining the calculated positions and orientations from the first apparatus to a 3D modelling apparatus; and

performing processing in the 3D modelling apparatus using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

12. A method according to claim 10 or claim 11, wherein the data defining the images is sent from the second apparatus to the first apparatus.

13. A method according to claim 10 or claim 11, wherein the data defining the images is sent from a third apparatus to the first apparatus.

14. A method according to claim 11, wherein the 3D modelling apparatus is the second apparatus to which the display enabling data is sent.

15. A method according to claim 11 or claim 14, wherein image data for each image for which the position and orientation of the imaging means has been calculated is sent from the first processing apparatus to the 3D modelling apparatus together with the data defining the calculated positions and orientations.

16. A method according to any of claims 10 to 15, further comprising the step of sending data defining details of the display apparatus from the second apparatus to the first apparatus, and wherein the display enabling data is generated by the first apparatus in

dependence upon the details of the display apparatus.

17. A method according to any of claims 10 to 16, further comprising the step of sending data defining a characteristic of the subject object from the second apparatus to the first apparatus, and wherein the display enabling data is generated by the first apparatus in dependence upon the characteristic of the subject object.

18. A method according to any preceding claim, wherein the computer processing apparatus are connected and data is transmitted therebetween via the Internet.

19. In a computer processing apparatus, a method of generating data defining a three-dimensional computer model of a subject object, comprising:

sending data from the apparatus to a second computer processing apparatus defining a calibration pattern of distinguishable features, thereby to enable the second apparatus to print the calibration pattern using a printer, and storing data defining the calibration pattern for subsequent use;

receiving data defining a plurality of images of the subject object and calibration pattern recorded with

imaging means at different relative positions and/or orientations;

performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

20. In a computer processing apparatus, an image processing method comprising:

sending data from the apparatus to a second computer processing apparatus defining a calibration pattern of distinguishable features, thereby to enable the second apparatus to print the calibration pattern using a printer, and storing data defining the calibration pattern for subsequent use;

receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

performing processing on the basis of the stored data defining the calibration pattern to calculate the

position and orientation at which at least some of the images were recorded; and

sending data defining the calculated positions and orientations to a 3D modelling apparatus to enable the 3D modelling apparatus to perform processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

21. A method according to claim 19 or claim 20, wherein the data defining the images is received from the second apparatus.

22. A method according to claim 19 or claim 20, wherein the data defining the images is received from a third apparatus.

23. A method according to claim 20, wherein the 3D modelling apparatus is the second apparatus to which the calibration pattern data is sent.

24. A method according to claim 20 or claim 23, wherein image data for images for which the position and orientation of the imaging means has been calculated is

sent to the 3D modelling apparatus together with the data defining the calculated positions and orientations.

25. A method according to any of claims 19 to 24, wherein data defining details of the printing apparatus is received from the second apparatus, and the data defining the calibration pattern sent to the second computer processing apparatus is generated in dependence upon the details of the printing apparatus.

26. A method according to any of claims 19 to 25, wherein data defining a characteristic of the subject object is received from the second apparatus, and wherein the data defining the calibration pattern sent to the second computer processing apparatus is generated in dependence upon the characteristic of the subject object.

27. A method according to any of claims 19 to 26, wherein the data sent to the second computer processing apparatus defining the calibration pattern defines the calibration pattern as a plurality of respective parts to be printed on separate recording media.

28. In a computer processing apparatus, a method of

generating data defining a three-dimensional computer model of a subject object, comprising:

sending data from the apparatus to a second computer processing apparatus defining a calibration pattern of distinguishable features, thereby to enable the second apparatus to display the calibration pattern on a display apparatus, and storing data defining the calibration pattern for subsequent use;

receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

performing processing on the basis of the stored data defining the calibration pattern to calculate the positions and orientations at which at least some of the images were recorded; and

performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

29. In a computer processing apparatus, an image processing method comprising:

sending data from the apparatus to a second computer processing apparatus defining a calibration pattern of

distinguishable features, thereby to enable the second apparatus to display the calibration pattern on a display apparatus, and storing data defining the calibration pattern for subsequent use;

receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

performing processing on the basis of the stored data defining the calibration pattern to calculate the positions and orientations at which at least some of the images were recorded; and

sending data defining the calculated positions and orientations to a 3D modelling apparatus to enable the 3D modelling apparatus to perform processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

30. A method according to claim 28 or claim 29, wherein the data defining the images is received from the second apparatus.

31. A method according to claim 28 or claim 29, wherein

the data defining the images is received from a third apparatus.

32. A method according to claim 29, wherein the 3D modelling apparatus is the second apparatus to which the calibration pattern data is sent.

33. A method according to claim 29 or claim 32, wherein image data for each image for which the position and orientation of the imaging means has been calculated is sent to the 3D modelling apparatus together with the data defining the calculated positions and orientations.

34. A method according to any of claims 28 to 33, wherein data defining details of the display apparatus is received from the second apparatus, and wherein the data defining the calibration pattern sent to the second computer processing apparatus is generated in dependence upon the details of the display apparatus.

35. A method according to any of claims 28 to 34, wherein data defining a characteristic of the subject object is received from the second apparatus, and wherein the data defining the calibration pattern sent to the

second computer processing apparatus is generated in dependence upon the characteristic of the subject object.

36. A method according to any of claims 19 to 35, wherein data is received from and sent via the Internet.

37. In a computer processing apparatus, a processing method comprising:

receiving data from a second computer processing apparatus defining a calibration pattern of distinguishable features;

controlling a printing apparatus to print the calibration pattern;

receiving data defining a plurality of images of the subject object and printed calibration pattern recorded with imaging means at different relative positions and/or orientations; and

sending data defining the images to the second apparatus.

38. In a computer processing apparatus, a method of generating data defining a three-dimensional computer model of a subject object, comprising:

receiving data from a second computer processing

apparatus defining a calibration pattern of distinguishable features;

controlling a printing apparatus to print the calibration pattern;

receiving data defining a plurality of images of the subject object and printed calibration pattern recorded with imaging means at different relative positions and/or orientations;

sending data defining the images to the second apparatus;

receiving data from the second apparatus defining the position and orientation at which at least some of the images were recorded; and

performing processing using the positions and orientations to generate data defining a three-dimensional computer model of the subject object.

39. A method according to claim 38, wherein image data for each image for which the position and orientation of the imaging means has been calculated is received from the second processing apparatus together with the data defining the positions and orientations.

40. A method according to any of claims 37 to 39,

further comprising the step of sending data defining details of the printing apparatus to the second apparatus to facilitate the generation of the data defining the calibration pattern.

41. A method according to any of claims 37 to 40, further comprising the step of sending data defining a characteristic of the subject object to the second apparatus to facilitate the generation of the data defining the calibration pattern.

42. A method according to any of claims 37 to 41, wherein the calibration pattern data received from the second computer processing apparatus defines the calibration pattern as a plurality of respective parts to be printed on separate recording media, and wherein the printing apparatus is controlled to print the calibration pattern as a plurality of respective parts on a plurality of recording media.

43. In a computer processing apparatus, a processing method comprising:

receiving data from a second computer processing apparatus defining a calibration pattern of

distinguishable features;

controlling a display apparatus to display the calibration pattern;

receiving data defining a plurality of images of the subject object and displayed calibration pattern recorded with imaging means at different relative positions and/or orientations; and

sending data defining the images to the second apparatus.

44. In a computer processing apparatus, a method of generating data defining a three-dimensional computer model of a subject object, comprising:

receiving instructions from a second computer processing apparatus defining a calibration pattern of distinguishable features;

controlling a display apparatus to display the calibration pattern;

receiving data defining a plurality of images of the subject object and displayed calibration pattern recorded with imaging means at different relative positions and/or orientations;

sending data defining the images to the second apparatus;

receiving data from the second apparatus defining the position and orientation at which at least some of the images were recorded; and

performing processing using the positions and orientations to generate data defining a three-dimensional computer model of the subject object.

45. A method according to claim 44, wherein image data for each image for which the position and orientation of the imaging means has been calculated is received from the second processing apparatus together with the data defining the positions and orientations.

46. A method according to any of claims 43 to 45, further comprising the step of sending data defining details of the display apparatus to the second apparatus to facilitate the generation of the data defining the calibration pattern.

47. A method according to any of claims 43 to 46, further comprising the step of sending data defining a characteristic of the subject object to the second apparatus to facilitate the generation of the data defining the calibration pattern.

48. A method according to any of claims 35 to 44, wherein data is received from and sent to the second apparatus via the Internet.

49. A method according to any of claims 1 to 19, 28, 38 and 44, further comprising the step of using the data defining the three-dimensional computer model to generate data for controlling an apparatus to create a physical model of the subject object.

50. A method according to any of claims 1 to 19, 28, 38, 44 and 49, further comprising the step of using the data defining the three-dimensional computer model to generate a physical model of the subject object.

51. A method using connected computer processing apparatus of generating data for controlling an apparatus to create a physical model of a subject object comprising:

sending from a first apparatus to a second apparatus data defining a calibration pattern of distinguishable features and storing data in the first apparatus defining the calibration pattern for subsequent use;

printing the calibration pattern using the data from

the first apparatus;

recording a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations, and sending data defining the images to the first apparatus;

performing processing in the first apparatus on the basis of the stored data defining the calibration pattern to calculate the positions and orientations at which at least some of the images were recorded; and

performing processing using the calculated positions and orientations to generate data for controlling an apparatus to create a physical model of the subject object.

52. A method using connected computer processing apparatus of generating data for controlling an apparatus to create a physical model of a subject object, comprising:

sending from a first apparatus to a second apparatus data defining a calibration pattern of distinguishable features and storing data in the first apparatus defining the calibration pattern for subsequent use;

displaying the calibration pattern using the data from the first apparatus;

recording a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations, and sending data defining the images to the first apparatus;

performing processing in the first apparatus on the basis of the stored data defining the calibration pattern to calculate the positions and orientations at which at least some of the images were recorded; and

performing processing using the calculated positions and orientations to generate data for controlling an apparatus to create a physical model of the subject object.

53. A system for generating data defining a three-dimensional computer model of a subject object using at least first and second connected computer processing apparatus, wherein:

the first apparatus comprises:

means for generating and sending to the second apparatus data defining a calibration pattern of distinguishable features to enable the second apparatus to print the calibration pattern with a printer;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object;

and wherein the second apparatus comprises:

means for receiving the calibration pattern data from the first apparatus; and

means for controlling a printing apparatus to print the calibration pattern in accordance with the data from the first apparatus to enable the recording of a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations.

54. A system for generating data defining a three-dimensional computer model of a subject object using connected computer processing apparatus, comprising:

a first apparatus comprising:

means for generating and sending to a second apparatus data defining a calibration pattern of distinguishable features to enable the second apparatus to print the calibration pattern with a printer;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for sending data defining the calculated positions and orientations to a 3D modelling apparatus;

a second apparatus comprising:

means for receiving the calibration pattern data from the first apparatus; and

means for controlling a printing apparatus to print the calibration pattern in accordance with the data from the first apparatus to enable the recording of a plurality of images of the subject object and calibration

pattern with imaging means at different relative positions and/or orientations; and

a 3D modelling apparatus comprising means for performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

55. A system according to claim 54, wherein the 3D modelling apparatus is the second apparatus to which the calibration pattern data is sent.

56. A system according to any of claims 53 to 55, wherein:

the second apparatus further comprises means for sending data defining details of the printing apparatus to the first apparatus; and

the first apparatus is arranged to generate the calibration pattern data in dependence upon the details of the printing apparatus.

57. A system according to any of claims 53 to 56, wherein:

the second apparatus further comprises means for sending data defining a characteristic of the subject

object to the first apparatus; and

the first apparatus is arranged to generate the calibration pattern data in dependence upon the characteristic of the subject object.

58. A system according to any of claims 53 to 57, wherein the means for generating and sending the calibration pattern data in the first apparatus is arranged to generate the data to define the calibration pattern as a plurality of respective parts to be printed on separate recording media.

59. A system for generating data defining a three-dimensional computer model of a subject object using at least first and second connected computer processing apparatus, wherein:

the first apparatus comprises:

means for generating and sending to the second apparatus data defining a calibration pattern of distinguishable features thereby to enable the second apparatus to display the calibration pattern on a display apparatus;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object;

and wherein the second apparatus comprises:

means for receiving the calibration pattern data from the first apparatus; and

means for controlling a display apparatus to display the calibration pattern in accordance with the data from the first apparatus to enable the recording of a plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations.

60. A system for generating data defining a three-dimensional computer model of a subject object using connected computer processing apparatus, comprising:

a first apparatus comprising:

means for generating and sending to a second apparatus data defining a calibration pattern of distinguishable features thereby to enable the second apparatus to display the calibration pattern on a display apparatus;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for sending data defining the calculated positions and orientations to a 3D modelling apparatus;

a second apparatus comprising:

means for receiving the calibration pattern data from the first apparatus; and

means for controlling a display apparatus to display the calibration pattern in accordance with the data from the first apparatus to enable the recording of a

plurality of images of the subject object and calibration pattern with imaging means at different relative positions and/or orientations;

and a 3D modelling apparatus comprising means for performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

61. A system according to claim 60, wherein the 3D modelling apparatus is the second apparatus to which the calibration pattern data is sent.

62. A system according to any of claims 59 to 61, wherein:

the second apparatus further comprises means for sending data defining details of the display apparatus to the first apparatus; and

the first apparatus is arranged to generate the calibration pattern in dependence upon the details of the display apparatus.

63. A system according to any of claims 59 to 62, wherein:

the second apparatus further comprises means for

sending data defining a characteristic of the subject object to the first apparatus; and

the first apparatus is arranged to generate the calibration pattern data in dependence upon the characteristic of the subject object.

64. A computer processing apparatus for generating data defining a three-dimensional computer model of a subject object, comprising:

means for generating and sending data to a second computer processing apparatus defining a calibration pattern of distinguishable features to enable the second apparatus to print the calibration pattern with a printer;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

65. A computer processing apparatus, comprising:

means for generating and sending data to a second computer processing apparatus defining a calibration pattern of distinguishable features to enable the second apparatus to print the calibration pattern with a printer;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for sending data defining the calculated positions and orientations to a 3D modelling apparatus to enable the 3D modelling apparatus to perform processing using the calculated positions and orientations to

generate data defining a three-dimensional computer model of the subject object.

66. Apparatus according to claim 64 or claim 65, wherein the means for generating the calibration pattern data is arranged to generate the data in dependence upon details of the printing apparatus received from the second apparatus.

67. Apparatus according to any of claims 64 to 66, wherein the means for generating the calibration pattern data is arranged to generate the data in dependence upon data defining a characteristic of the subject object received from the second apparatus.

68. Apparatus according to any of claims 64 to 67, wherein the means for generating the calibration pattern data is arranged to generate the data to define the calibration pattern as a plurality of respective parts to be printed on separate recording media.

69. A computer processing apparatus for generating data defining a three-dimensional computer model of a subject object, comprising:

means for generating and sending data to a second computer processing apparatus defining a calibration pattern having a predetermined pattern of distinguishable features thereby to enable the second apparatus to display the calibration pattern on a display apparatus;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for performing processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

70. A computer processing apparatus, comprising:

means for generating and sending data to a second computer processing apparatus defining a calibration pattern of distinguishable features thereby to enable the second apparatus to display the calibration pattern on a

display apparatus;

means for storing data defining the calibration pattern for subsequent use;

means for receiving data defining a plurality of images of the subject object and calibration pattern recorded with imaging means at different relative positions and/or orientations;

means for performing processing on the basis of the stored data defining the calibration pattern to calculate the position and orientation at which at least some of the images were recorded; and

means for sending data defining the calculated positions and orientations to a 3D modelling apparatus to enable the 3D modelling apparatus to perform processing using the calculated positions and orientations to generate data defining a three-dimensional computer model of the subject object.

71. Apparatus according to claim 69 or claim 70, wherein the means for generating the calibration pattern data is arranged to generate the data in dependence upon details of the display apparatus received from the second apparatus.

72. Apparatus according to any of claims 69 to 71, wherein the means for generating the calibration pattern data is arranged to generate the data in dependence upon data defining a characteristic of the subject object received from the second apparatus.

73. A storage device storing instructions for causing a programmable processing apparatus to become operable to perform a method as set out in at least one of claims 19 to 36.

74. A signal conveying instructions for causing a programmable processing apparatus to become operable to perform a method as set out in at least one of claims 19 to 36.

75. A storage device storing instructions for causing a programmable processing apparatus to become configured as an apparatus as set out in at least one of claims 64 to 72.

76. A signal conveying instructions for causing a programmable processing apparatus to become configured as an apparatus as set out in at least one of claims 64

to 72.

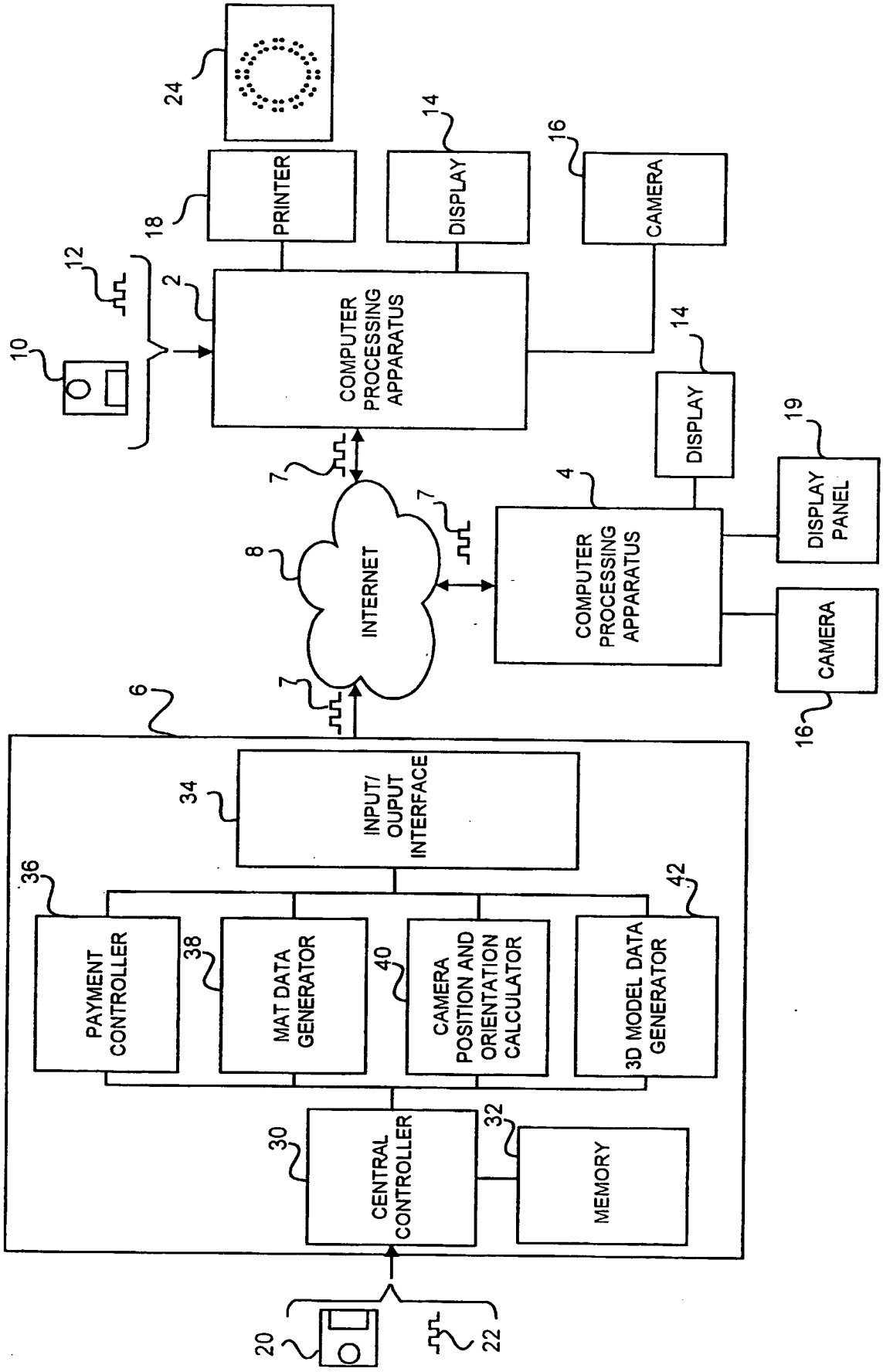
24
PRINTER
18
DISPLAY
14
CAMERA
16
12
2
COMPUTER PROCESSING APPARATUS
10
14
DISPLAY
19
DISPLAY PANEL
7
4
7
8
INTERNET
COMPUTER PROCESSING APPARATUS
CAMERA
16
7
6
34
INPUT/ OUPUT INTERFACE
36
42
PAYMENT CONTROLLER
38
MAT DATA GENERATOR
40
CAMERA POSITION AND ORIENTATION CALCULATOR
3D MODEL DATA GENERATOR
30
CENTRAL CONTROLLER
32
MEMORY
20
22

FIG. 1

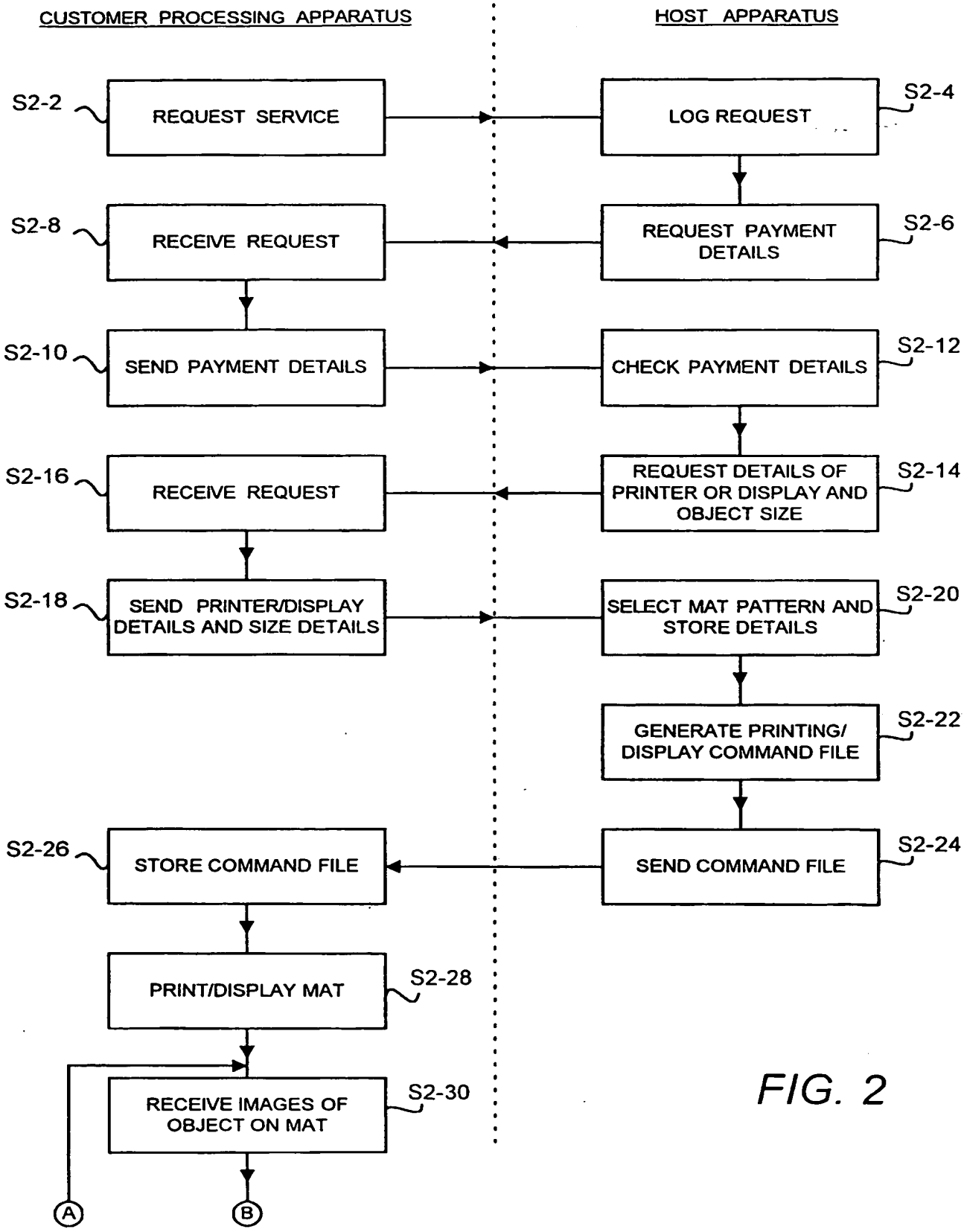
CUSTOMER PROCESSING APPARATUS
HOST APPARATUS
S2-2
REQUEST SERVICE
S2-4
LOG REQUEST
S2-8
RECEIVE REQUEST
REQUEST PAYMENT DETAILS
S2-6
S2-10
SEND PAYMENT DETAILS
CHECK PAYMENT DETAILS
S2-12
S2-16
RECEIVE REQUEST
REQUEST DETAILS OF PRINTER OR DISPLAY AND OBJECT SIZE
S2-14
S2-18
SEND PRINTER/DISPLAY DETAILS AND SIZE DETAILS
SELECT MAT PATTERN AND STORE DETAILS
S2-20
GENERATE PRINTING/ DISPLAY COMMAND FILE
S2-22
S2-26
STORE COMMAND FILE
SEND COMMAND FILE
S2-24
PRINT/DISPLAY MAT
S2-28
RECEIVE IMAGES OF OBJECT ON MAT
S2-30
A
B

FIG. 2

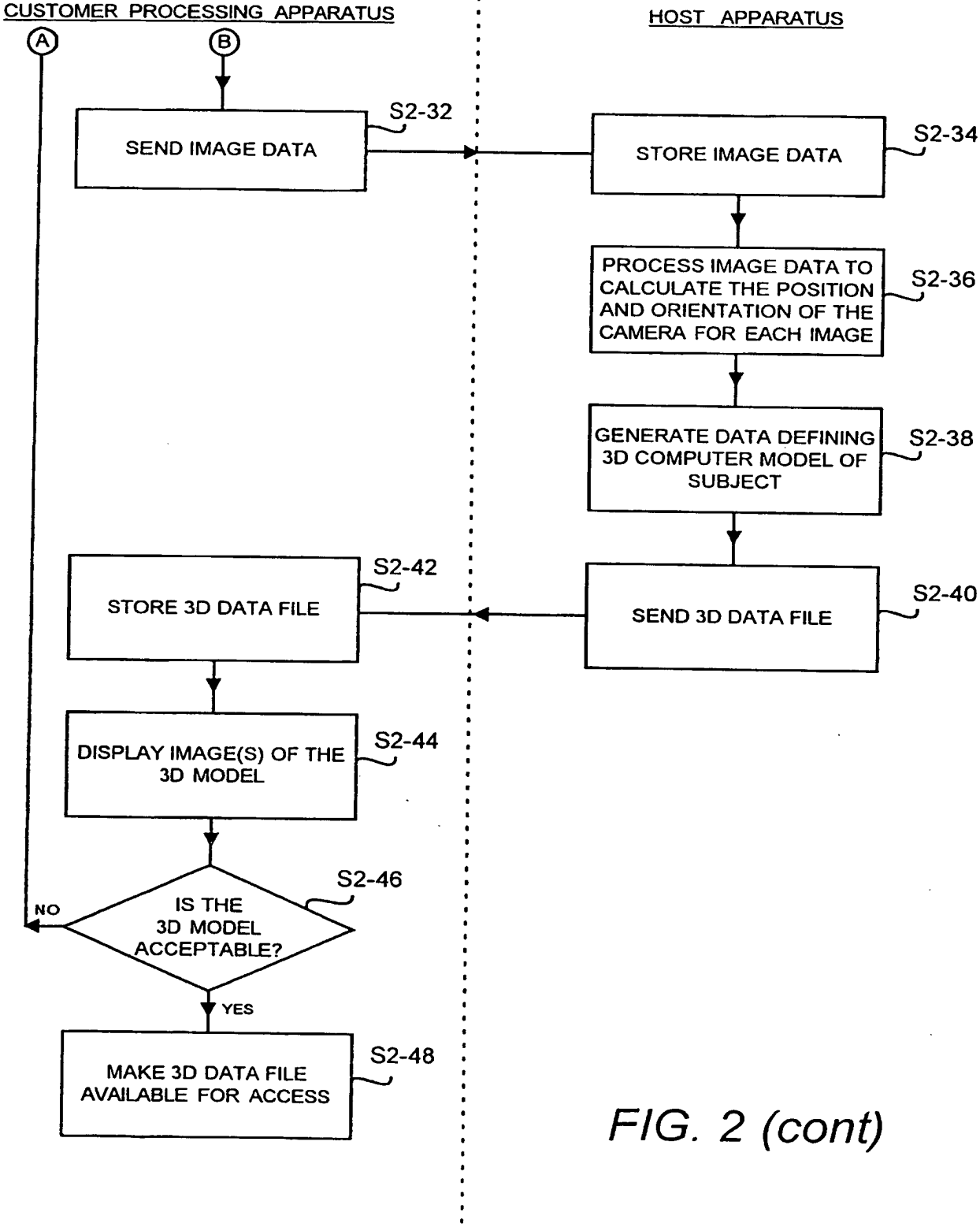
CUSTOMER PROCESSING APPARATUS
HOST APPARATUS
A
B
SEND IMAGE DATA
S2-32
STORE IMAGE DATA
S2-34
PROCESS IMAGE DATA TO CALCULATE THE POSITION AND ORIENTATION OF THE CAMERA FOR EACH IMAGE
S2-36
GENERATE DATA DEFINING 3D COMPUTER MODEL OF SUBJECT
S2-38
SEND 3D DATA FILE
S2-40
STORE 3D DATA FILE
S2-42
DISPLAY IMAGE(S) OF THE 3D MODEL
S2-44
IS THE 3D MODEL ACCEPTABLE?
S2-46
NO
YES
MAKE 3D DATA FILE AVAILABLE FOR ACCESS
S2-48

FIG. 2 (cont)

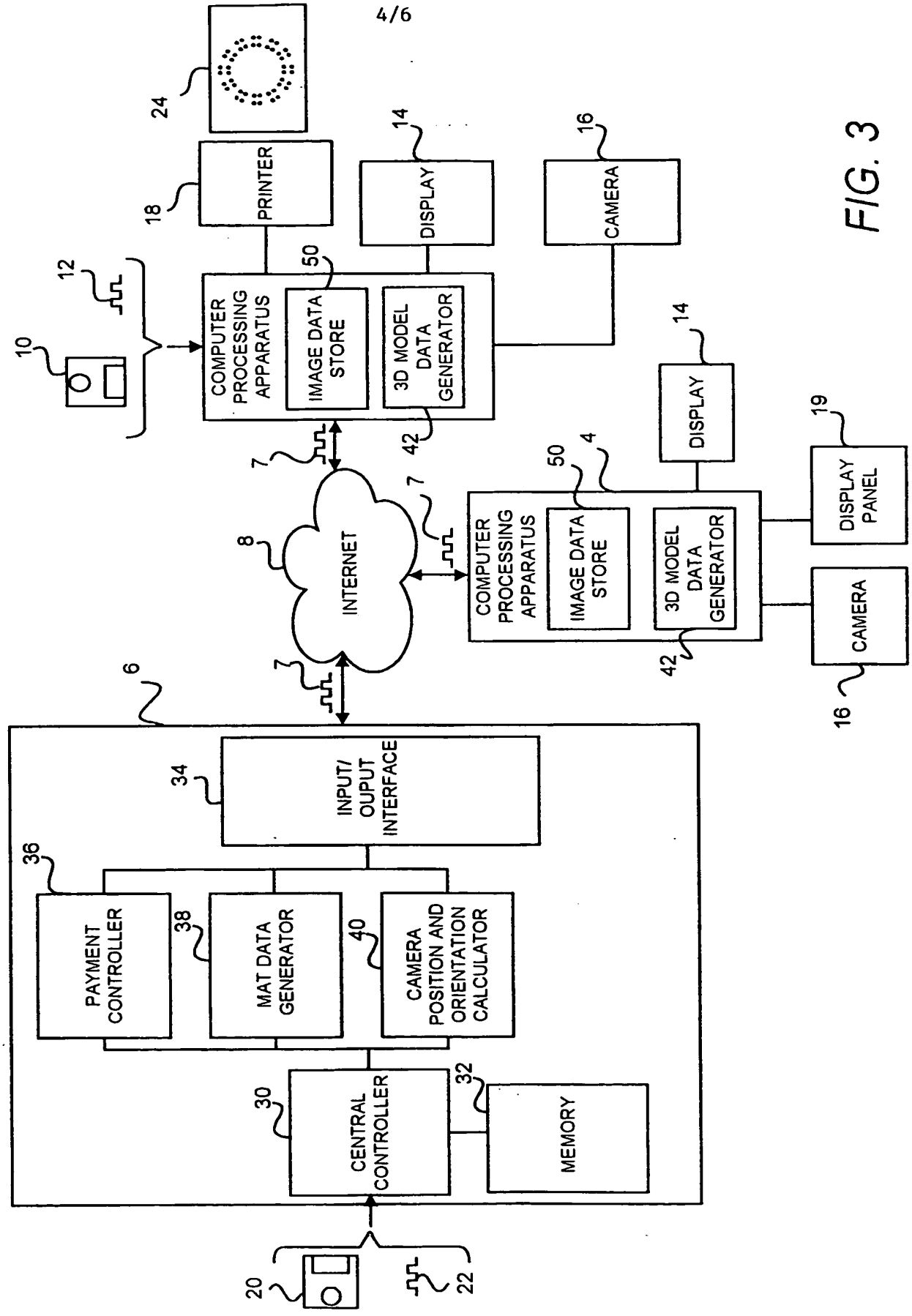
24
PRINTER
18
DISPLAY
14
CAMERA
16
12
10
COMPUTER PROCESSING APPARATUS
50
IMAGE DATA STORE
3D MODEL DATA GENERATOR
42
7
INTERNET
8
7
DISPLAY
14
50
4
COMPUTER PROCESSING APPARATUS
IMAGE DATA STORE
3D MODEL DATA GENERATOR
42
DISPLAY PANEL
19
CAMERA
16
6
INPUT/ OUPUT INTERFACE
34
36
PAYMENT CONTROLLER
38
MAT DATA GENERATOR
40
CAMERA POSITION AND ORIENTATION CALCULATOR
30
CENTRAL CONTROLLER
32
MEMORY
20
22

FIG. 3

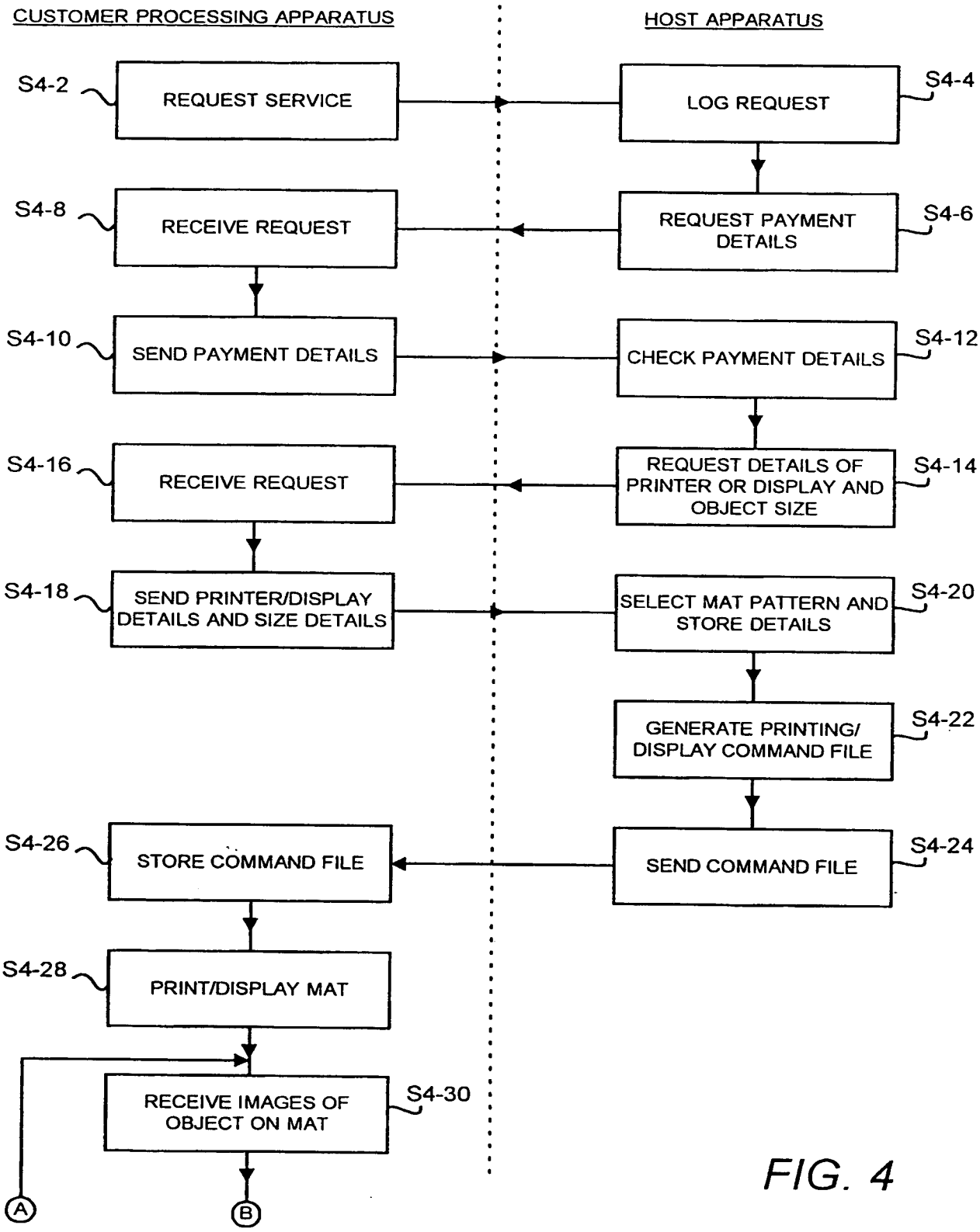
CUSTOMER PROCESSING APPARATUS
HOST APPARATUS
S4-2
REQUEST SERVICE
LOG REQUEST
S4-4
S4-8
RECEIVE REQUEST
REQUEST PAYMENT DETAILS
S4-6
S4-10
SEND PAYMENT DETAILS
CHECK PAYMENT DETAILS
S4-12
S4-16
RECEIVE REQUEST
REQUEST DETAILS OF PRINTER OR DISPLAY AND OBJECT SIZE
S4-14
S4-18
SEND PRINTER/DISPLAY DETAILS AND SIZE DETAILS
SELECT MAT PATTERN AND STORE DETAILS
S4-20
GENERATE PRINTING/ DISPLAY COMMAND FILE
S4-22
S4-26
STORE COMMAND FILE
SEND COMMAND FILE
S4-24
S4-28
PRINT/DISPLAY MAT
RECEIVE IMAGES OF OBJECT ON MAT
S4-30
A
B

FIG. 4

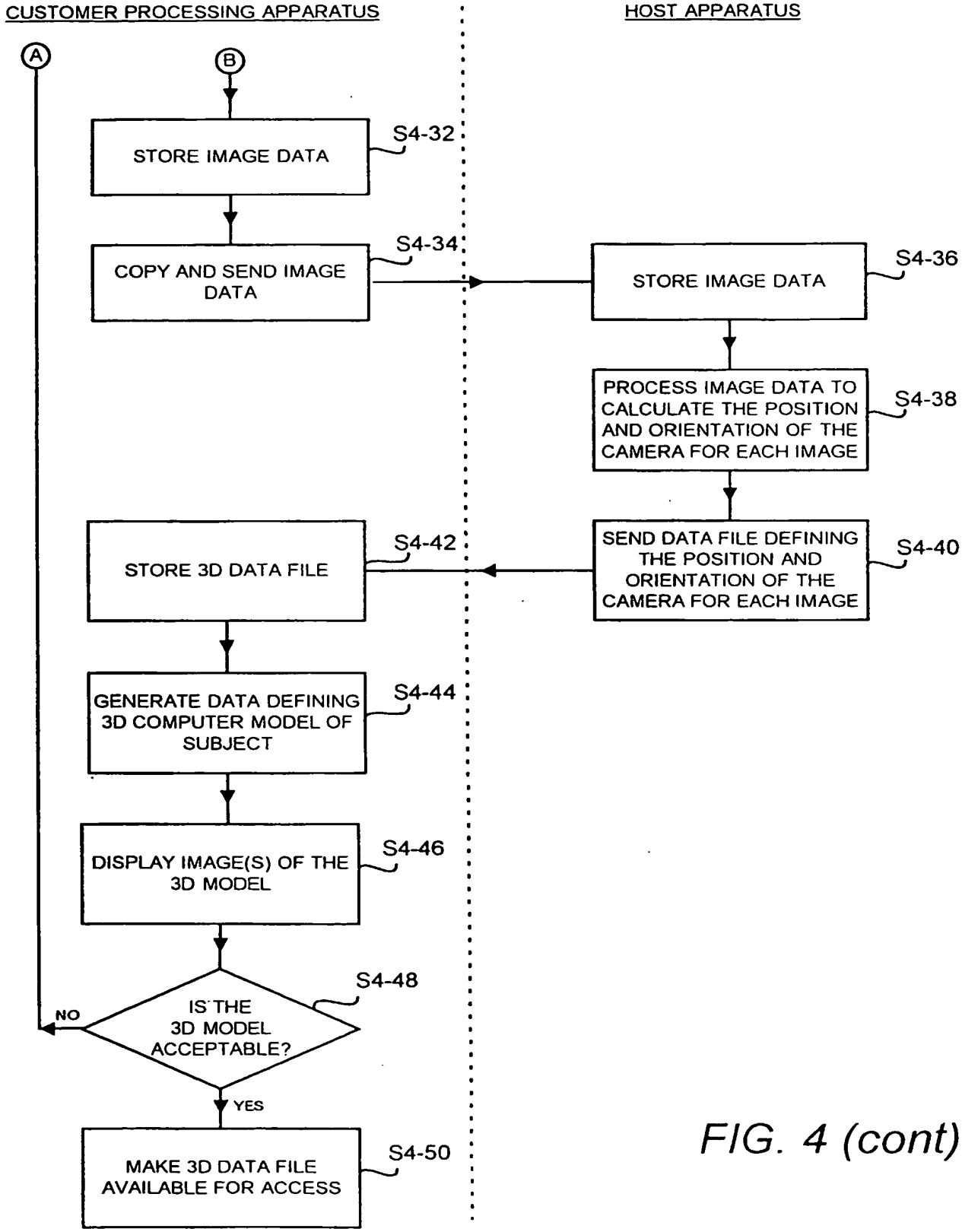
CUSTOMER PROCESSING APPARATUS
HOST APPARATUS
A
B
STORE IMAGE DATA
S4-32
COPY AND SEND IMAGE DATA
S4-34
STORE IMAGE DATA
S4-36
PROCESS IMAGE DATA TO CALCULATE THE POSITION AND ORIENTATION OF THE CAMERA FOR EACH IMAGE
S4-38
SEND DATA FILE DEFINING THE POSITION AND ORIENTATION OF THE CAMERA FOR EACH IMAGE
S4-40
STORE 3D DATA FILE
S4-42
GENERATE DATA DEFINING 3D COMPUTER MODEL OF SUBJECT
S4-44
DISPLAY IMAGE(S) OF THE 3D MODEL
S4-46
IS THE 3D MODEL ACCEPTABLE?
S4-48
NO
YES
MAKE 3D DATA FILE AVAILABLE FOR ACCESS
S4-50

FIG. 4 (cont)